Programmable Metallization Cell Memory Based on Ag-Ge-S and Cu-Ge-S Solid Electrolytes

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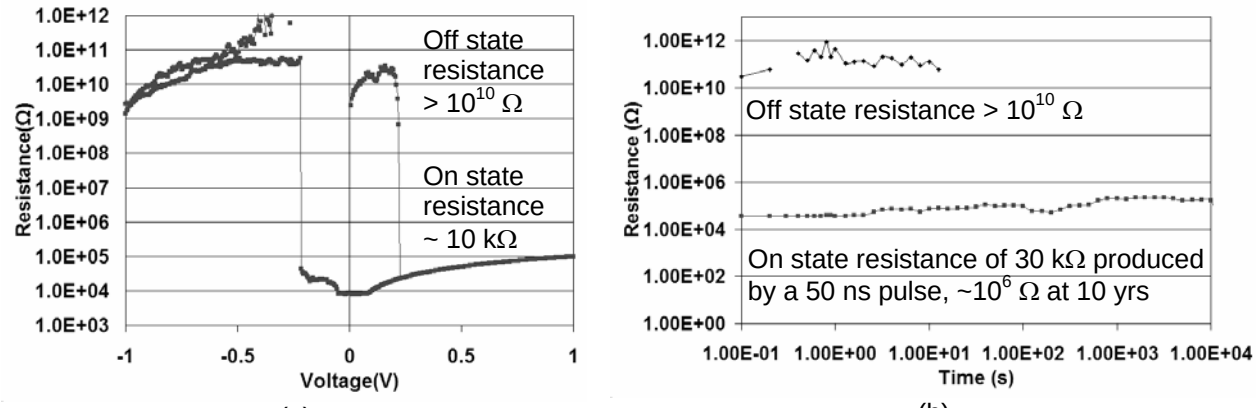
In our earlier work on Programmable Metallization Cell (PMC) memory, we focused on germanium selenide-based devices, the key attributes of which were fast low voltage and current operation, excellent scalability, solid retention and endurance, and a simple fabrication process. One consideration for Se-based devices is that they do not tolerate processing conditions much beyond 200 ^{o}C and so relatively low temperature back-end-of-line (BEOL) processing is necessary for integration with CMOS. In this paper, we present the electrical characteristics of PMC devices based on Ag-Ge-S and Cu-Ge-S solid electrolytes. These materials have excellent thermal stability and readily withstand the temperatures used in current BEOL processes. Fig. 1 illustrates the electrical behavior of a 350 nm diameter device with a tungsten bottom electrode, a 60 nm thick Ag-Ge-S solid electrolyte, and a silver top electrode, following an anneal at 430 ^{o}C. Fig. 1(a) gives a typical resistance-voltage plot for a device programmed at 10 μA, which goes from an off resistance over 10^{10} Ω to an on resistance of 10 kΩ at a 220 mV write threshold and transitions to its off state at -220 mV. Fig. 1(b) shows the room temperature off and on resistance as a function of time, measured using a 100 mV sensing signal. The on state of approximately 30 kΩ was programmed using a 50 ns pulse and is projected to remain more than 4 orders of magnitude lower than the off state after ten years.



(a) (b)

Fig. 1. Electrical behavior of a 350 nm diameter Ag-Ge-S based PMC device following an anneal at 430 ^{o}C. (a) Resistance-voltage plot of a device programmed at 10 μA with 220 mV write threshold and -220 mV erase threshold. (b) Room temperature off and on resistance as a function of time.